

Contents

1	Introduction	1
1.1	Matter–Antimatter Asymmetry in the Universe	1
References		2
2	Symmetries	3
2.1	Discrete Symmetries in Classical Physics	3
2.1.1	Parity \mathcal{P}	3
2.1.2	Time Reversal \mathcal{T}	4
2.1.3	Dipole Moments	4
2.2	Discrete Symmetries in Quantum Systems	5
2.2.1	Particle–Antiparticle Conjugation	5
2.2.2	Violation of Mirror Symmetry – Parity Violation in Weak Interactions	5
2.2.3	Violation of \mathcal{C} Symmetry, and \mathcal{CP} Invariance	6
2.2.4	\mathcal{CP} Invariance and Neutral K Mesons	6
2.2.5	Discovery of \mathcal{CP} Violation	7
2.3	Discrete Symmetries in Quantum Mechanics	9
References		11
3	Mixing and Decay of Neutral Mesons	13
3.1	Particle–Antiparticle Mixing	13
3.2	Decays of Neutral Mesons	15
3.2.1	Time-Dependent Schrödinger equation	15
3.2.2	Decay Asymmetries and \mathcal{CP}	18
References		20
4	Models of \mathcal{CP} Violation	21
References		25
5	The Neutral K Meson System	27
5.1	Mass Eigenstates and \mathcal{CP} Eigenstates	27
5.2	Isospin Decomposition	27
5.3	K_L – K_S Regeneration	31
5.4	Interference Between Decay Amplitudes of K_L and K_S	34

5.4.1	2π Decay	34
5.4.2	Semileptonic Decays	35
5.5	Detection of K^0 Decays	38
5.5.1	Charged Decay Modes	38
5.5.2	Neutral Decay Modes	41
5.5.3	Detectors Measuring Charged and Neutral Decay Modes Simultaneously	45
5.5.4	NA31	45
5.5.5	NA48	47
5.5.6	E731	48
5.5.7	kTeV	50
5.5.8	CLEAR	51
5.6	Elucidation of \mathcal{CP} Violation in K^0 Decays (I): Search for $\Im m(\varepsilon'/\varepsilon)$	53
5.6.1	Interference Experiments Behind a Regenerator	53
5.6.2	The Significance of the Phase Φ_{+-}	54
5.6.3	$K_L - K_S$ Mass Difference	54
5.6.4	Rate of $K_L \rightarrow \pi^+ \pi^-$ Decay	55
5.6.5	Measurements of the Phase Φ_{+-} in Interference Experiments Behind a Regenerator	59
5.6.6	Measurements of Φ_{+-} in Vacuum Interference Experiments	62
5.6.7	Measurements of the Phase Difference $\Phi_{00} - \Phi_{+-}$	65
5.6.8	Measurement of Φ_{+-} from a Tagged Pure Strangeness State	66
5.6.9	Charge Asymmetry in Semileptonic Decays	68
5.6.10	Parameters of \mathcal{CP} Violation in the K^0 System: $\Im m(\varepsilon'/\varepsilon)$	69
5.7	Elucidation of \mathcal{CP} Violation in K^0 Decays (II): Discovery of Direct \mathcal{CP} Violation in $\Re e(\varepsilon'/\varepsilon)$	72
5.7.1	Significance of the Double Ratio R	72
5.7.2	The NA31 Experiment: First Evidence for Direct \mathcal{CP} Violation	72
5.7.3	The Experiment E731 at Fermilab	75
5.7.4	The kTeV Experiment at Fermilab	78
5.7.5	The NA48 Experiment	82
5.7.6	Conclusions About Direct \mathcal{CP} Violation, $\Re e(\varepsilon'/\varepsilon)$ and the Wu-Yang Triangle	89
	References	92
6	The Neutral B Meson System	95
6.1	Phenomenology of Mixing in the Neutral B Meson System	95
6.2	Detection of B Meson Decays	98
6.3	Belle	99
6.4	BABAR	101

6.5	Lifetime measurements	105
6.6	Measurements of $B_d^0 - \bar{B}_d^0$ Mixing	107
6.7	Search for B_s^0 Mixing	109
6.8	Experiments on \mathcal{CP} Violation in B^0 Decays	111
6.9	Search for Direct \mathcal{CP} Violation in B^0 Decays	117
	References	121
7	Weak Quark Mixing and the CKM Matrix	123
	References	136
8	Conclusion	139
	References	139
	Index	141